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Reports
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DATA COLLECTION FOR DEVELOPING SITE INDEX CURVES FOR ENGELMANN SPRUCE, CORKBARK FIR, SOUTHWESTERN WHITE PINE AND BLUE SPRUCE IN ARIZONA, NEW MEXICO AND SOUTHWESTERN COLORADO

PREPARED FOR:
U.S. FOREST SERVICE
OCTOBER 21, 1985

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October 21, 1985

Mr. Carl Edminster
U.S. Forest Service
240 Prospect Street
Fort Collins, CO 80526-2098

Dear Carl,

It is a pleasure to turn in the final report and data set for developing site index curves for Engelmann Spruce, Corkbark Fir, Blue Spruce, and Southwestern White Pine in Arizona, New Mexico and southern Colorado. The project has been exciting to work on from beginning to end and I feel the data presented here is the best data set that could possibly have been collected in 14 months.

If you have any questions, please feel free to call. I look forward to working with you writing up the results of this study for publication and hope to work with you again in the future.

Sincerely,

David J Cooper

David Cooper
Thorne Ecological Institute

DC:dd
Enclosure

Data Collection for Developing Site Index Curves for Engelmann Spruce, Corkbark Fir, Southwestern White Pine and Blue Spruce in Arizona, New Mexico and southwestern Colorado

Final Report

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Submitted to : U.S. Forest Service, 21 October 1985

Introduction

The most widely followed practice in describing forest site quality is the site index curve (Jones 1969; Husch et al. 1973; Daubenmire 1976). Site index curves represent the relationship between height and age of dominant and codominant trees from measured plots. The data necessary for developing site index curves is derived from height and age measurements of selected trees, ranging from young to old, in temporary plots representing the range of habitat types, elevations, and site qualities found in the study area (Champman 1921; Osborne and Schumacher 1935; Chapman and Meyer 1949).

To develop site index curves for application to a large geographic area, such as the Southwestern United States, a large data base is necessary from the entire geographic region. This data must account for variation in habitats, climates, topography and soils found in the region. However, since height growth of trees varies by habitat type (Daubemnire 1961; Deitschman and Green 1965; Roe 1967; Hoffman 1976; Moir and Ludwig 1979) some workers have suggested that separate site-index curves be constructed for different habitat types (Daubenmire 1961; Hoffman, 1976).

In uneven aged stands, growth rates of very young trees (10-30 years) are often suppressed and site indices derived from young trees are poorly correlated with growth of older trees (Alexander 1966; Jones 1966). To overcome this problem, age at breast height (4.5 feet) is often used (Minor 1964; Alexander 1967; Edminster and Jump 1976) instead of base age. Other suggestions for estimating site quality of uneven aged stands

include adjusting for periods of suppression (Stage 1963), using maximum height at a specified reference diameter (McClintock and Bickford 1957), careful selection of site trees from smaller even aged groups within the uneven aged stand (Frothingham 1921) and classifying potential productivity into classes based on similarity in soils or plant communities (Daubenmire 1961, 1976). The dynamics of canopy gaps is also an important factor for identifying sites in which young trees can grow relatively unsuppressed in uneven aged, moderately dense stands.

Field data for site index curves should be carefully collected from stands representing a wide range of age classes, stand compositions and densities, and, site trees should have no evidence of past injuries from disease, insects, broken crowns due to snow or wind, or unusual lean or curve. Increment cores at breast height should show a relatively regular growth pattern throughout the life of the tree, with no signs of prolonged past suppression. In reality, few trees have not experienced some periods of suppressed growth.

Methods

Stands representing a variety of elevations, aspects, habitat types, and topographic conditions were chosen for sampling. Stands having adequate site trees, lack ofno physical defects or diseases, and for microhabitats in which trees appeared to be free-growing. Most stands chosen had several potential site trees. What appeared to be the best tree in each stand was sampled first. If the increment core showed a

consistent pattern of ring widths the tree was kept. Ten years was the maximum length of time a tree could be supressed and still be kept. Other trees in the stand were then sampled and compared with the first tree. Older trees had to be taller, and younger trees shorter. Trees with rotten or unreadable cores were discarded. If a taller tree in the same ten year age class was sampled in the same stand, the shorter tree was discarded. On occasion two trees in the same age class were kept in the same stand. This is especially true of older trees for all species, and Corkbark fir in all age classes (except the youngest) because good site trees were difficult to find. If more than one species of tree occurred in this stand sampling included them all. Trees of the same species were compared because different species usually had different site indices for any single stand. Dominant, codominant, and intermediate trees were sampled, and where good site trees were found one tree in each ten year age class was sampled. Trees up to 210 years were most desirable, and a few trees older than this were kept.

At the end of each day, the tree data was entered into square matrices used to keep track of data. One matrix was created for each species. The matrix has age on the x axis and estimated site index on the y axis. A goal of this study was to try to get an equal number of trees in each ten year age class from 10-210 years, for each site index. Site index was estimated for each stand using the published site index curves of Alexander (1967) for Engelmann spruce, Corkbark fir, and Blue spruce, and the curves of Minor (1964) for southwestern white pine. Every tree kept was entered into this matrix so it could be seen where

gaps existed in the data set, both in age classes and site indices. Each day an attempt was made to fill these sample gaps.

Problems were encountered in sampling each tree species involved in this study and the following paragraphs describe what these problems were and how they were handled:

Engelmann Spruce. This species is the most sought after lumber tree of the four species in this study. Many areas have been logged. Many roads in the National Forests visited were built for or by lumbering concerns. Thus, much of the easily accessible areas have been lumbered. Older trees do not occur in most of these areas, and in the square matrix fewer individuals in these older squares are present. In the Apache and Gila National Forests several stands were sampled which contained Engelmann Spruce and Corkbark Fir which had site indexes well above the curves of Alexander (1967), estimated at approximately site index 130 or 140. In these high site index stands only young trees were present, although in a few stands some trees up to 140 years were found still growing at the same rate as the younger trees. In stands with lower site indices, such as were found at higher elevations and on snowy sites, few old trees were considered site trees. Most trees are eventually broken by wind or snow loading, especially when tree height gets above the canopy.

Corkbark Fir. This was the most difficult species in this study to find adequate site trees. A large percentage of the trees rot at a fairly young age, in most areas less than 150 years, and few sound older trees could be found. The wood is

quite soft and the trees tend to wind throw or experience crown damage, especially when they get taller. The greatest concentration of sound older corkbarks was found in the Abla-Sesa habitat type on Sierra Blanca in the Lincoln National Forest. In stands with high and low site indices older site trees were absent, and at low site indices young site trees were also absent. Young trees are usually suppressed by snow loading in open stands near treeline. The most abundant seedlings under most spruce-fir canopies are Corkbarks and rapid vertical growth is released by formation of a treefall canopy gap, or by high-grade logging. Many Corkbarks which appeared to be site trees actually were suppressed for a large portion of their early life. One factor making Corkbarks abundant in some areas is that logging operations will not take them. Selective cutting of Engëlmann spruce and Douglas-fir leaves stands dominated by Corkbarks, but rarely were any found in situations like this that had not experienced severe and prolonged supression demonstrated in their increment cores. Thus, few were acceptable site trees. Approximately 1200 to 1400 Corkbarks were chosen as appearing to be site index trees during this study, but examination of increment cores showed many of them to be unsatisfactory, usually due to suppression in their youth.

Blue Spruce. Blue spruce were easy to work with because they were rarely rotten or supressed. They did not occur in any abundance in the Gila or Lincoln National Forests but were well distributed throughout the remainder of the study area. The problem with this species is that it appears to be short-lived, with individuals rarely above 140 years old. Most stands were of

moderately high site index because they occupied moist habitats. Low site indices were rare, or non-existant. An attempt was made to sample an equal number of Blue Spruce along stream courses and in mixed conifer forests on upland slopes.

Southwestern White Pine. This species occurred most abundantly in the Lincoln and Apache National Forests, although good stands also occurred in the Santa Fe, Carson and Gila National Forest. Some stands containing this species were also sampled in Colorado. Good site trees were difficult to find for several reasons. Crowns are very susceptible to breakage, and the boles rot nearly as badly as do Corkbark fir. They also have thin bark and most old trees have huge fire scars on their uphill side which do not become covered by bark, and thus rot quickly. Few older trees could be kept although hundreds were examined. The species is also somewhat shade intolerant, and successional in a variety of habitat types. Young trees are usually severely supressed. Because so little is known about the ecology of this species, more than the required 400 trees were sampled.

The taxonomy of this species is not entirely clear; apparently this species and Limber Pine intergrade in northern New Mexico and southern Colorado. For this study, sampling included only trees which grew in stands mixed with Douglas-fir, White Fir, and other species, had a single bole, grew upright and had bluish-green leaves. The cores in many trees are almost unreadable with a hand lens, or even a dissecting microscope because a dark band of summer wood does not always occur. Also

the rings of some cores are very tight. Where rings could not be easily counted with a hand lens in the field the tree was discarded. The variability of growth of this species, even within a single stand was great. Some stands sampled in the Valle Vidal unit of the Carson National Forest occurred in mixed stands with Douglas-fir, Engelmann Spruce, and Corkbark fir yet had very low site indices, in the high 30´s or low 40´s. These may represent trees which are crosses with Limber Pines although morphologically they looked identical to Southwestern White Pines found farther south, and all had a single bole and the other key characteristics of this species. These trees occurred in stands 287 and 290. Pines sampled in Colorado, called Southwestern White Pines, may also represent a mix with Limber Pine although their site index was around 50. These stands are numbers 45 and 55.

Results

Field work for the present study was conducted in Arizona, New Mexico and southwestern Colorado. All major high elevation mountain regions were visited and studied. The majority of data was collected in the San Juan, Carson, Santa Fe, Lincoln, Apache and Kaibab National Forests. Small amounts of data were also collected in the Coconino, Gila, and Rio Grande National Forests. Because the distribution of commercial Engelmann spruce - Corkbark fir forests are very limited in the American Southwest, these areas were intensively studied, although the data collected was from the largest geographical area possible within these areas.

The original plan was to collect 20% of the data in Colorado, and 40% each in New Mexico and Arizona. In New Mexico 60% would be collected in the northern portion of the state and 40% in the southern portion of the state. In Arizona 50% each would be collected in the northern and southern part of the state. The final data differ from this original plan somewhat, although an effort was made to abide by it. Southwestern White Pine occurs primarily in the southern parts of Arizona and New Mexico, and most of these trees were sampled in the Apache and Lincoln National Forests. Because significant habitat types and populations of Engelmann Spruce, Corkbark Fir and Blue Spruce also occur in these areas, more tree data was collected in these areas than originally predicted. The Kaibab National Forest has a fairly limited high elevation area and only one Engelmann Spruce - Corkbark Fir habitat type (Abies lasiocarpa - Juniperus communis habitat type) occurs there, and no Southwestern White Pine occurs. Thus, fewer trees were sampled on the Kaibab than originally planned to avoid redundancy in the data set.

The San Juan Mountains of Colorado have great ecological diversity, yet were not a primary focus in this study. The greatest diversity and largest mountain area in the southwest occurs in northern New Mexico where the southern San Juan, Jemez and Sangre de Cristo Mountains occur. These are in the Carson and Santa Fe National Forests. Much of the high country in the Santa Fe National Forest is in wilderness areas, and was not easily accessible. For this reason more trees were collected in the Carson National Forest than Santa Fe National Forest. Little time was spent on the San Francisco Peaks in the Coconino

National Forest in Arizona because almost all of the high country is a wilderness area. However, a small data set was collected from that area to have some data on the Picea engelmannii - Geum rossii and Abies lasiocarpa - Lathyrus arizonicus habitat types which occur only in the San Francisco Peaks area.

I was advised not to collect much data on the Gila National Forest because there is little high country and little commercial timbering of spruce - fir forests. However, several stands were sampled to collect data on the regional variation to be found in that area. Three stands sampled in the Gila had the tallest trees sampled in this entire study (stands 360, 361, 362). In these stands Engelmann Spruce was up to 150 feet in height, and Corkbark Fir up to 140 feet in height. No comparable heights were found anywhere else in the study area.

Data for 2,359 trees in 407 stands are presented as the final data set for this study. They occurred in 52 habitat types. A breakdown of tree species sampled by forest region is presented below:

	Picea engelmannii	Abies lasiocarpa	Picea pungens	Pinus strobiformis	Total
San Juan-Rio Grande	183	65	105	25	378
Carson-Santa Fe	274	282	66	58	680
Lincoln-Gila	37	52	17	238	344
Kaibab-Coconino	153	145	86	4	388
Apache	156	111	110	192	569
Total	803	655	384	517	2359

Percentage of total trees collected by region is as follows:

Colorado = 16 % (almost all in the San Juan)

Northern New Mexico = 29 % (Carson = 20 % and Santa Fe = 9 % : 66 % of New Mexico trees)

Southern New Mexico = 15 % (almost all in the Lincoln : 34 % of New Mexico trees)

Southern Arizona = 24 % (all in the Apache : 60 % of Arizona trees)

Northern Arizona = 16 % (almost all in the Kaibab: 40 % of Arizona trees)

State totals are as follows:

Colorado = 16 % (378 trees)

New Mexico = 43 % (1024 trees)

Arizona = 41 % (957 trees)

Within the geographic areas data was collected specifically in the following locales:

Colorado. Data was collected in the upper Dolores, and Animas River valleys in the western San Juans, and from the vicinity of Wolf Creek pass. In addition data was collected in the vicinity of La Manga Pass in the southern San Juans.

Northern New Mexico. In the Sangre De Cristo Range data was collected in the Valle Vidal district, the region of Red River, Cabresto Creek and Hondo Creeks. High country was accessed around Cerro Vista and Gallegos Peaks southeast of Taos, Elk Mountain in the Pecos River valley, and in the vicinity of Santa Fe Ski area. In the San Juan Mountains the area around Hopewell

Lake and Canjilon Lakes were sampled. In the Jemez mountains we traveled throughout the high country.

Southern New Mexico. In the Smoky Bear district of the Lincoln National Forest the only high country is around Sierra Blanca and Rio Bonito. High country also exists in the Capitan Mountains, but due to poor weather conditions it was not accessible. In the Cloudcroft district high country was found most of the way from Cloudcroft to Sunspot, and in the many tributaries of Rio Penasco and Sacramento River. In the Gila National Forest the only area visited is in the Mogollon Mountains mostly between Bear Wallow Mountain and the Town of Mogollon. The stand with the very tall trees noted earlier is along road 153, .8 miles south of the junction of forest roads 119 and 119 A.

Southern Arizona. All data was collected in the Apache National Forest. The largest portion was collected in the area between Alpine and the Mogollon Rim, including the many side roads heading east and west in this area. Data was also collected in the area of Big Lake and the Mt. Baldy Wilderness area.

Northern Arizona. Almost all data was collected on the Kaibab Plateau in the highest southcentral part of the region. Most was collected in an area between Telephone Hill, the National Park Service North Rim entrance station, Fire Point and Big Springs Ranger station. On the Coconino National Forest trees were sampled in the area between the Snow Bowl Ski area and the summit of Humphreys Peak.

In the work plan for this project habitat types which most likely would be sampled were listed and given numbers, however almost twice as many habitat types were actually sampled. The following list contains all habitat types sampled and the number used to code data sheets. This list takes precedence over the previous list. Habitat types were keyed out using the publications cited in the work plan. In addition, two new habitat types were also sampled which are not described in any published literature. I was told of these habitat types by Will Moir, and provided with a description of the stands composition. These two habitat types are the Psme-Hodu and Abla-Cage (Carex geyeri). All other data is coded according to the information presented in the work plan.

1. Abla-Sabr
2. Able-Moss
3. Able-Meci
4. Pien-Vamy-Popu
5. Abla-Vamy-Libo
6. Abla-Vamy-Rupa
7. Abla-Vamy
8. Abla-Rupa
9. Abla-Eres
10. Abla-Sesa
11. Abla-Juco
12. Abla-Laar
13. Abla-Cage
14. Pien-Sabr
15. Pien-Hesp
16. Pien-Erex
17. Pien-Seca
18. Pien-Acgl
19. Pien-Gero
20. Pipu-Popr
21. Pipu-Swse
22. Pipu-Libo
23. Pipu-Cafo
24. Pipu-Fear
25. Pipu-Erex
26. Pipu-Frov
27. Pipu-Aruv
28. Psme-Hodu
29. Psme-Quga

30. Psme-Fear
31. Psme-Sparse
32. Psme-Scree
33. Psme-Brci
34. Abco-Hodu
35. Abco-Acgl
36. Abco-Erex
37. Abco-Sparse
38. Abco-Quga
39. Abco-Fear
40. Abco-Rone
41. Abco-Muvi
42. Abco-Acgr
43. Abco-Aruv
44. Pipo-Quga
45. Pipo-Fear
46. Pipo-Muvi
47. Piar-Rimo
48. Pifl-Aruv
49. Piar-Feth
50. Piar-Fear
51. Abco-Vamy
52. Abco-Cafo

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